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THESIS

THE EFFECT OF PERSONALITY STYLE AND TEAM ORGANIZATION ON TEAM PERFORMANCE

by

Timothy Warwick Hannen

December 2007

Thesis Advisor: Lawrence G. Shattuck
Second Reader: Nita Lewis Miller

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13. ABSTRACT (maximum 200 words)

The continual advancement of technology and the increasing complexity of the operational environments for the military have necessitated the proliferation of team-based operations. The use of personality styles is one possible way to go beyond normal demographics when attempting to predict team performance. This study provides an analysis of two personality styles and their potential for predicting team performance.

The tenets of Human Systems Integration (HSI) state that it is critical to view the human as a component of any system. This study examined the effect of team personality style on team performance. Additionally, the effect of team command and control organization was examined by building upon the Office of Naval Research's Adaptive Architecture for Command and Control (A^2C^2) project.

The results of the study were inconclusive. There was no significant difference between the performance of teams high in conscientiousness and high in agreeableness (A+C+) and the performance of teams low in conscientiousness and low in agreeableness (A-C-). Furthermore, there was no difference between teams utilizing different command and control organizations. The results of the study reveal that, currently, A+C+ and A-C- personality styles are not viable as selection tools Further research concerning the many possible personality styles is required.

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THE EFFECT OF PERSONALITY STYLE AND TEAM ORGANIZATION ON TEAM PERFORMANCE

Timothy W. Hannen
Lieutenant, United States Navy
B.S., Tulane University, 1999

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December 2007

Author: Timothy Warwick Hannen

Approved by: Lawrence G. Shattuck, Ph.D.
Thesis Advisor

Nita Lewis Miller, Ph.D.
Second Reader

James N. Eagle, Ph.D.
Chairman, Department of Operations Research

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EXECUTIVE SUMMARY

With the rapid advancement of technology and the increasingly complex nature of the operations that the military is involved in, the concept of forming teams based solely on military qualifications requires examination. While qualifications and proficiencies are an important part of team performance, there are other, more abstract, aspects of team formation that must be addressed. The use of personality surveys to identify an individual's personality traits provides a tool with potential predictive value. And, while, previous research regarding the impact of individual personality traits on team performance is certainly beneficial, the fact that an individual personality is comprised of more that one trait must be taken into consideration. This study continues previous research of the effects of personality traits on team performance by examining the effects of personality styles, or the combination of two personality traits, on team performance.

In addition to examining different personality styles, this study also builds upon research conducted by the Office of Naval Research's Adaptive Architecture for Command and Control (A^2C^2) program. This study also investigates the effect of team command and control organization and resource allocation on team performance.

The basic tenet of Human Systems Integration (HSI) is that the human is an integral part of any complex system. The human considerations include, but extend past, physical considerations, such as ergonomics. These considerations must also encompass concepts such as personality and other abstract qualities. For the purpose of this study, the

impact of human personality styles on team performance was examined through the use of the C3Fire computer simulation.

Results of the study do not reveal any conclusive results regarding the effect of team personality style or team organization on team performance. Team performance was measured through analysis of the team's performance in the computer simulation and also through examination of team communication during the simulations.

Descriptive and inferential statistical analysis showed no statistical difference between the performance or the communications of the teams with regards to both team personality style and team organization. Specifically, the study found no significant difference between the performance of teams high in conscientiousness and high in agreeableness (A+C+) and the performance of teams low in conscientiousness and low in agreeableness (A-C-). Furthermore, there was no difference between teams utilizing different command and control organizations. Team performance was measured not only by performance with regard to the C3Fire program, but also with regards to team communication. Descriptive and inferential statistical analysis showed no statistical difference in the performance or communications of the teams with regards to either team personality style or team organization. The results of the study reveal that, currently, personality is not viable as a selection or placement tool. Further research is required concerning all the possible personality styles, focusing on military teams in military activities.

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I. INTRODUCTION

A. PROBLEM STATEMENT

The use of teams in the military is vital. The rationale behind the use of teams is that the combination of the individual skills, knowledge and attitudes of individuals will result in improved mission accomplishment (Peeters, Van Tuijl, Rutte, & Reyman, 2006). Watch teams, flight crews and duty sections are just a few of the ways that the military organizes personnel to accomplish missions. Furthermore, with improvements in technology, team members no longer have to be located in the same building, city, or even country. However, along with the countless advantages that teamwork provides, it is also possible to assemble a team whose performance is detrimental to the mission. The individual team members are what determine if a team is successful.

To fully benefit from teamwork, there has to be a way to increase the likelihood that an assembled team is going to be successful. The military, specifically the United States Navy, is attempting to reduce the manning levels for many of its platforms, thereby making it even more important to maximize the interactions between the personnel. Without knowing prior work history or previous personnel relations, a viable way to predict whether or not individuals will function effectively as a team is through the identification of individual personality traits. The NEO Five Factor Inventory (NEO-FFI) developed by Costa and McCrae identifies five individual traits that make up an individual personality: openness, conscientiousness, extraversion,

agreeableness and neuroticism. Additionally, Costa and Piedmont identify 40 personality styles, which are the interactions between different levels of any two of the traits (Costa & Piedmont, 2003). By determining and analyzing the personality traits and styles of the individuals in a team, it may be possible to predict the success of that team.

B. OBJECTIVES

The purpose of this thesis is to examine the effectiveness of personality styles, as defined by the NEO-FFI, in predicting team performance. The specific goals of this thesis include:

- To determine a method for combining individuals based on personality styles, in order to increase the likelihood of the formation of a successful team.
- To utilize a pre-existing computer simulation to provide quantitative results regarding team performance.
- To evaluate the results with respect to Human Systems Integration (HSI) and the possible effects on the broader application of HSI.

C. RESEARCH QUESTIONS

The specific research questions addressed in this study include:

- Are personality styles an accurate predictor of team success or failure?
- If so, how do homogenous groups comprised of individuals high in agreeableness and

conscientiousness (A+C+) perform relative to homogenous teams of individuals low in agreeableness and conscientiousness (A-C-)

D. BACKGROUND

Forming successful teams is not as simple as blindly choosing personnel in the hopes that they will work well together. Individual personality traits and styles must be taken into consideration when forming the teams. There are several personality tests that are designed to measure individual personality traits, such as the NEO-FFI and the Myers-Briggs Type Indicator (MBTI). Problems arise when attempting to determine which traits, when combined, will result in a successful team. Numerous studies have been conducted regarding this exact question (Barrick & Mount, 1991; Kichuk & Wiesner, 1997; Peeters et al., 2006; van Vianen & De Dreu, 2001) but there has yet to be a definitive answer.

Additionally, the issue of team composition must be addressed. A team can be either homogeneous or heterogeneous with respect to team members' personality traits. Homogeneous teams would consist of team members with similar personality styles, while heterogeneous teams would be made up of individuals with varying personality styles. There have been studies (Neuman, Wagner, & Christiansen, 1999; Kichuk & Wiesner, 1997) concerning the effect of team composition on team performance with varied results. Both studies found that team composition effects vary for different personality traits.

A great majority of today's military is involved in some type of team related work. Soldiers in Iraq are

organized for most missions by fire teams, squads, platoons and companies as they patrol the streets of Baghdad. Sailors onboard U.S. Navy warships are assigned to various watch teams and are expected to stay vigilant. Pilots and Flight Officers combine to form flight crews to optimize the capabilities of the aircraft. Often there appears to be no rhyme or reason to how the personnel that make up the teams are selected.

Numerous factors can contribute to the failure of a team to perform well. Personality conflicts, lack of motivation and insufficient oversight or tasking are only a few of the causes of team failure. If there is a way to increase the chance of success for a team before the team is even formed, that option must be explored. As the complexity of the technology increases and the number of personnel decreases, it is vital that the military identify a method for optimizing teamwork.

E. HUMAN SYSTEMS INTEGRATION (HSI)

HSI is a process that acknowledges the critical role of the human in any complex system. “It is an interdisciplinary approach that makes explicit the underlying tradeoff across the HSI domains, facilitating optimization of total system performance” (Naval Postgraduate School). The purpose of HSI within the Department of Defense (DoD) acquisition process is “…to optimize total system performance, minimize total ownership costs, and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system” (DoD Instruction 5000.2).

This thesis evaluates the effect of individual personality styles on overall team performance and contributes to selected domains of HSI. As viewed by the U.S. Navy, HSI is comprised of eight domains (Naval Postgraduate School):

- Manpower
- Personnel
- Training
- Human Factors Engineering
- Survivability
- Health Hazards
- System Safety
- Habitability

This thesis focuses on three of the eight domains: manpower, personnel and training. The manpower domain concentrates on the numerical personnel requirements needed to operate, maintain, and support the system (Archer et al., 2003). The military, the Navy specifically, is moving towards significantly reducing the manning on many of its platforms, e.g. the Littoral Combat Ship (LCS). The LCS is a small surface ship designed to operate in littoral waters. With its 3,000 ton displacement, the LCS is approximately the same size as a U.S. Coast Guard HAMILTON Class cutter (3,250 tons) and slightly smaller than a U.S. Navy OLIVER HAZARD PERRY Class frigate (4,100 tons). The LCS, however, has a proposed manning of 40 core personnel, while the cutter has a crew of 167 and the frigate’s crew is approximately 300 personnel. Any insight regarding how to maximize team performance should provide valuable guidance on achieving maximum performance with a limited number of personnel.

The personnel domain relates to the knowledge, skills and abilities of the humans that are required to operate, maintain, and support a system. The personnel domain involves both the physical and the cognitive attributes possessed by the individual (Archer et al., 2003). Currently, determining which personnel will be detailed to a command based on personality traits and styles may be premature, but it is possible that watch team performance could be improved if individual personality traits and styles were taken into account. As it stands now, personnel are assigned to watch teams somewhat randomly, as long as the watch team meets all the required Personnel Qualification Standards (PQS) and all essential watch stations are filled.

The training domain is concerned with ensuring that the training requirements and programs will allow the personnel to properly operate, maintain and support the system (Archer et al., 2003). In a team environment each team member completes training that is tailored to meet his or her specific function within the team. With the trend towards reduced manning requirements, each team member will be called upon to assume more duties within the team, thus making each team member's performance that much more critical to the performance of the team. Knowledge of how individuals' personality traits and styles interact would be beneficial in assigning individual roles within the team, and therefore individual training requirements.

F. THESIS ORGANIZATION

In Chapter II, literature regarding individual personality traits and styles, team performance, and

Adaptive Architectures for Command and Control (A^2C^2) is discussed. Chapter III outlines the methods used to conduct the experiment. Chapter III also includes a description of C3fire, the microworld that was used to assess team performance. Chapters IV and V present the results of the experiment, discuss conclusions and propose follow-on research in related areas.

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II. LITERATURE REVIEW

This literature review is divided into five sections. The first section focuses on individual personality traits and how they are determined using the NEO-FFI. The first section also discusses a relatively new concept, personality styles. The second section discusses team performance and how team members interact and share information. The third section examines the concept of naturalistic decision making and its effect on team performance. The fourth section examines an ongoing series of team research efforts called adaptive architecture for command and control (A^2C^2). The fifth section discusses communication within a team.

A. THE NEO-FFI, PERSONALITY TRAITS AND PERSONALITY STYLES

"The Revised NEO Personality Inventory (NEO PI-R) is a concise measure of the five major dimensions, or domains, of personality and some of the more important traits or facets that define each domain" (Costa & McCrae, 1992). The research in this thesis was conducted utilizing the NEO Five Factor Inventory (NEO-FFI), a shorter version of the NEO PI-R. The NEO-FFI focuses only on the five personality traits and omits the associated facets. The NEO PI-R was introduced in 1985, at the time including the five domains of personality, but facets for only three of the five. The facets of each domain are distinct characteristics of each domain that allow for further distinction within a domain. The inventory has since been updated to include facets for all five domains. The NEO PI-R consists of 240 questions, while the NEO-FFI is comprised of only 60 questions. The use

of the NEO-FFI for this thesis is due to time constraints and the scope of the research.

The NEO-FFI presents respondents with questions such as “I keep my belongings neat and clean” and “I have a lot of intellectual curiosity” (Costa & McCrae, 2003). The respondent chooses one of the following answers: strongly disagree, disagree, neutral, agree, or strongly agree. The answer to each question is assigned a value and the respondent is assigned a measure on each of the five personality domains. The NEO-FFI presents 12 questions pertaining to each individual domain. While the facets of each domain are not evaluated in the NEO-FFI, they will be further discussed here in order to elaborate on the dimensions of each domain.

Openness (O) is the degree to which an individual is imaginative and curious. Open individuals are curious, not only about their external environment, but also about their internal selves. Individuals high in openness are more likely to involve themselves in new situations and are more ready to accept novel ideas and values (Costa & McCrae, 1992). The facets associated with openness are fantasy, aesthetics, feelings, actions, ideas and values (Costa & McCrae, 1992). Individuals who score low in the openness domain tend to be more conservative in nature, preferring the familiar and customary to the abnormal (Costa & McCrae, 1992).

In separate meta-analyses, Mount, Barrick and Stewart (1998) and Peeters et al. (2006) conducted studies of existing literature in an attempt to consolidate existing research regarding individual personality and team performance. Mount et al. analyzed 11 studies while Peeters

et al. examined 10 studies. Mount et al. found a positive correlation between openness and team performance (r=.17). Peeters et al. found minimal correlations between average team openness score and team performance (r=.03), and between variance in team openness scores and overall team performance (r=-.01).

Kichuk and Wiesner (1997) conducted an experiment involving 419 first year undergraduate Engineering students. The students were assigned to one of eight groups based on their schedules. Groups were further divided into teams of three. Each team was required to construct a bridge from a set of provided materials. The bridges were scored based on pre-set values for length, width, height, and strength. The results showed that team average openness score (r=.03, p<.01) and team openness score variation (r=-.01, p<.01) have a minimal correlation with team performance.

Neuman, Wagner, and Christensen (1999) conducted a study of the relationship between team personality composition and job performance. The research focused on the team personality elevation (TPE): the average level of a given trait for a team, and the team personality diversity (TPD): the variability of personality traits within a team. The study utilized 328 employees of a large retail organization. The employees were organized into four-person teams based on geographic location and product specialty. The employees were administered two personality tests similar to the NEO-FFI to determine team TPE and TPD. Team performance was based on a customer service rating and task completion score. The study showed a positive correlation (r=.31, p<.01) between openness TPE and team performance.

There was negative (r=-.10, p<.05) correlation between openness TPD and team performance.

Openness is the least concretely defined of the five traits and has been alternately labeled autonomy (van Vianen & De Dreu, 2001) and intellect (Kichuk & Wiesner, 1997). There is no evidence which shows that openness is correlated to levels of autonomy or intelligence.

Conscientiousness (C) is defined as being thorough, meticulous and task-oriented. Facets of the conscientiousness trait are competence, order, dutifulness, achievement striving, self-discipline, and deliberation (Costa & McCrae, 1992). People who score low on the conscientiousness scale are considered to be less exacting in the methods they use to accomplish their goals. Conscientiousness is widely considered to be an accurate indicator of individual performance (Peeters et al., 2006, Mount et al., 1998, Kichuk & Wiesner, 1997).

The Mount et al. (1998) meta-analysis shows a positive correlation between team mean conscientiousness score and team performance (r=.26), as does the Peeters et al. (2006) meta-analysis (r=.21). The Peeters et al. study also shows a negative correlation between score variance and performance (r=-.24).

The Neuman, Wagner, and Christensen (1999) study regarding TPE and the TPD revealed that a high TPE for conscientiousness showed positive correlation to team performance (r=.40, p<.01), while the TPD score showed negative correlation (r=-.08, p<.05). Contrarily, the Kichuk and Wiesner (1997) study found positive correlation between average team conscientiousness score and team performance

(r=.07, p<.05) and a negative correlation between variation in conscientiousness scores and team performance (r=-.22, p<.01).

Barrick, Stewart, Neubert and Mount (1998) conducted a study relating team composition and team performance. The study used 652 individuals working on 51 teams. Teams consisted of personnel assembling small appliances, personnel assembling small electronic equipment, and fabrication and maintenance teams in two rubber manufacturing plants. Team performance was determined based on supervisor ratings in eight categories: knowledge of tasks, quality of work, quantity of work, initiative, interpersonal skills, planning and allocation, commitment to the team, and overall team performance. The study found that higher average team conscientiousness was associated with higher performance (r=.26, p<.05). It also found a negative correlation between group score variation and team performance (r=-.33, p<.05), suggesting that the inclusion of a single individual low in conscientiousness is detrimental to team performance.

Halfhill, Nielsen, Sundstrom, and Weilbaecher (2005) conducted a study of 422 military personnel at a United States Air National Guard base. The personnel were evaluated in 47 existing teams, ranging from three to 14 members. A NEO-FFI adapted for military work teams was administered to determine personality styles and team performance was measured through supervisor evaluations. The study found that team performance was positively correlated with average team conscientiousness (r=.34, p<.01). The study also found minimal correlation between group score variation and team performance (r=.05, p>.05).

A study conducted by van Vianen and de Dreu (2001) examined 24 teams involved in drilling operations in Maryland and Virginia. The study also included 28 teams of students at the University of Amsterdam involved in a research project. Team performance for both groups was based on supervisory ratings. As the tasks performed by the drilling teams were different from the tasks performed by the students, the rating criteria were altered accordingly. The results reveal a positive correlation between team performance and average team conscientiousness score (r=.09), but a negative correlation between score variation and performance (r=-.20).

Extraversion (E) is the degree to which a person is outgoing and is willing to interact with other people. The facets of extraversion are warmth, gregariousness, assertiveness, activity, excitement-seeking and positive emotions (Costa & McCrae, 1992). Extraverts are normally considered to be leadership types, as they are usually the ones that interact with all members of a team and are most vocal in stating their opinions and ideas. People who score low on the extraversion scale should be viewed as low in extraversion, rather than the opposite of extraversion. “Introverts are reserved rather than unfriendly, independent rather than followers, even-paced rather than sluggish…introverts are not unhappy or pessimistic” (Costa & McCrae, 1992).

The Mount et al. (1998) meta-analysis showed a positive correlation between team mean extraversion score and team performance (r=.14), while the Peeters et al. (2006) meta-analysis showed minimal correlations between mean

extraversion score and team performance (r=.04) and team extraversion score variation (r=.06).

The Kichuk and Wiesner (1997, (r=.07, p<.01)), van Vianen and De Dreu (2001, (r=.05)), and Neuman et al. (1999, (r=.07)) studies all found a minimal correlation between average team extraversion score and performance. The Barrick et al. (1998) study found a positive correlation (r=.12, p<.05). Additionally, the Kichuk and Wiesner (r=-.06, p<.05), Barrick et al. (1998, (r=.02, p<.05)), and van Vianen and De Dreu (r=.07) studies all showed similar, minimal correlation between team score variation and team performance. Neuman et al. however, showed a positive correlation between extraversion TPD and team performance (r=.26, p<.05).

Agreeableness (A) is the extent to which a person is willing to compromise and accept others' opinions. A person who is high in agreeableness is also more willing to help others. The facets associated with agreeableness include trust, straightforwardness, altruism, compliance, modesty, and tender-mindedness (Costa & McCrae, 1992). A disagreeable person is egocentric, skeptical of others' intentions and competitive. The research concerning the effect of agreeableness on team performance is varied.

The meta-analysis by Mount et al. (1998) proposes that agreeableness is a valid predictor of team performance (r=.35), specifically in jobs involving cooperation and personal interaction. The Peeters et al. (2006) meta-analysis shows that there is a positive correlation between average team agreeableness score and team performance (r=.51) while there is negative correlation between score variance and performance (r=-.13).

The study conducted by Barrick et al. (1998) shows that while team performance is positively correlated with agreeableness ($r=.34$, $p<.05$), team score variance is negatively correlated with team performance ($r=-.08$, $p<.05$).

Halfhill et al. (2005) found a positive correlation between performance and group agreeableness average ($r=.28$, $p<.05$). Their study also found a negative correlation with variance in group agreeableness ($r=-.34$, $p<.05$). Similarly, Neuman et al. (1999) found that agreeableness TPE was positively correlated to team performance ($r=.41$, $p<.01$). However, the Neuman et al. (1999) study showed that agreeableness TPD positively correlated to performance ($r=-.13$). The van Vianen and De Dreu (2001) study also shows positive correlation between average score and performance ($r=.17$) and negative correlation between score variance and performance ($r=-.11$)

The Kichuk and Wiesner (1997) research shows minimal correlation between both average agreeableness score ($r=-.02$, $p<.05$) and score variation ($r=-.02$, $p<.05$), and team performance. The study further suggests that agreeableness "…does not seem to be related to team performance for teams that are capable of adequate performance" (Kichuk & Wiesner, 1997, p. 213).

Neuroticism (N), also referred to as lack of emotional stability, is the ability, or lack thereof, of an individual to deal with a situation rationally and calmly. The facets of neuroticism are anxiety, angry hostility, depression, self-consciousness, impulsiveness and vulnerability.

The Mount et al. (1998) meta-analysis found a positive correlation between average team neuroticism score and team performance ($r=.18$), as did the Peeters et al. (2006) meta-

analysis (r=.14). The Peeters et al. study also found a positive correlation between the score variance and team performance (r=.16).

The Kichuk and Wiesner (1997) study involving undergraduate engineering students showed that a team's composite neuroticism score was minimally correlated to team performance (r=.01, p>.05), while the team score variance showed positive correlation with team performance (r=-.12). The van Vianen and De Dreu (2001) study shows that the average team score (r=.06) and the variance in the team score (r=.03) are minimally correlated to team performance.

Barrick et al. (1998) suggest that team's average neuroticism score is positively correlated to team performance (r=.24, p<.05), while the team score variance is positively correlated with team performance (r=.12, p<.05). Neuman et al. (1999) suggest a positive correlation between TPE and team performance (r=.17) and a positive correlation between TPD and team performance (r=.23, p<.05).

Domain	Facets	Domain	Facets
Openness	Fantasy	Agreeableness	Trust
	Aesthetics		Straightforwardness
	Feelings		Altruism
	Actions		Compliance
	Ideas		Modesty
	Values		Tender-Mindedness
Conscientiousness	Competence	Neuroticism	Anxiety
	Order		Angry Hostility
	Dutifulness		Depression
	Achievement		Self-Consciousness
	Self-Discipline		Impulsiveness
	Deliberation		Vulnerability
Extraversion	Warmth		
	Gregariousness		
	Assertiveness		
	Avtivity		
	Excitement-Seeking		
	Positive Emotions		

Figure 1. NEO Personality Traits and Associated Facets (From NEO PI-R: Professional Manual, 1992, p. 34.)

As discussed, there is a significant amount of literature regarding the effect of the traits of individual team members on team performance (Peeters et al., 2006; Mount et al., 1998; Barrick et al., 1998; van Vianen & Dreu, 2001; Neuman et al., 1999; Kichuk & Wiesner, 1997; and Halfhill et al., 2005). It would seem, however, that with the existence of five separate personality traits, the mere existence or absence of one trait alone would not be enough to cause an entire team to be successful or unsuccessful. Thus, the interaction between the individual traits, other aspects of the person, such as experiences, and the environment have to be taken into consideration (Costa & Piedmont, 2003). To explore these other interactions, the

concept of personality styles has been introduced by Costa and McCrae (1998). Personality styles look specifically at the interactions between the different personality traits. According to Costa, the area of personality styles is an uncultivated research area (P. T. Costa, Jr., personal communication, August 9, 2007).

When determining personality styles, the NEO-FFI is scored, assigning a value of 0 to 4 for the answer to each question. The total for the questions related to each trait are then totaled to create a raw trait score. The raw scores for each trait are then correlated to a normative score. Normative scores above 50 are considered to be positive (+) for that personality trait while scores below 50 are negative (-). To determine the personality style, the positive or negative form of that trait is combined with other individual traits. Table 1 shows all possible personality styles.

Style of Interests		Style of Impulse	
E+O-	Mainstream Consumers	N+C-	Undercontrolled
E+O+	Creative Interactors	N+C+	Overcontrolled
E-O-	Homebodies	N-C-	Relaxed
E-O-	Introspectors	N-C+	Directed
Style of Interactions		**Style of Activity**	
E+A-	Leaders	E+C-	Funlovers
E+A+	Welcomers	E+C+	Go-Getters
E-A-	Competitors	E-C-	The Lethargic
E-A+	The Unassuming	E-C+	Plodders
Style of Well-Being		**Style of Attitudes**	
N+E-	Gloomy Pessimists	O+A-	Free-Thinkers
N+E+	Overly Emotional	O+A+	Progressive
N-E-	Low-keyed	O-A-	Resolute Believers
N-E+	Upbeat Optimists	O-A+	Traditionalists
Style of Defense		**Style of Learning**	
N+O-	Maladaptive	O+C-	Dreamers
N+O+	Hypersensitive	O+C+	Good Students
N-O-	Hyposensitive	O-C-	Reluctant Scholars
N-O+	Adaptive	O-C+	By-the-Bookers
Style of Anger Control		**Style of Character**	
N+A-	Tempermental	A+C-	Well-Intentional
N+A+	Timid	A+C+	Effective Altruists
N-A-	Cold-Blooded	A-C-	Undistinguished
N-A+	Easy-Going	A-C+	Self-Promoters

Table 1. Personality Styles (from Paradigms of Personality Assessment, 2003, p. 270-275.)

B. TEAM PERFORMANCE

It is a common misconception that the formation and implementation of a team will invariably lead to success (Salas & Fiore, 2004). When the complexity of a task exceeds the cognitive ability of a single individual and the formation of teams is necessary (Cooke, Salas, Cannon-Bowers & Stout, 2000), there are many factors that must be considered in order to allow a team to have the best chance of success. Teamwork can be considered to be the end result

of the collaboration of individual cognition, behaviors and attitudes (Salas & Fiore, 2004).

Shared cognition between team members is a good predictor of team effectiveness, as it suggests that team members have similar knowledge and use this shared knowledge to guide their coordinated efforts (Cannon-Bowers & Salas, 2001). An analysis of a team's shared cognition can also be used to diagnose potential problems within the team, such as lack of communication. By comparing the knowledge that each individual is utilizing, it can be determined what shared knowledge is missing (Cannon-Bowers & Salas, 2001). Cannon-Bowers and Salas (1990) and Cannon-Bowers, Salas and Converse (1993) refer to team cognition as team mental models.

Researchers (Cannon-Bowers et al., 1993; Duncan, Rouse, Johnston, Cannon-Bowers, Salas, & Burns, 1996; and Rouse, Cannon-Bowers, & Salas, 1992) have proposed at least four domains that are integral to the team cognition process: knowledge of equipment used by the team, knowledge of team tasks and requirements, knowledge of other team members, and knowledge of attitudes/beliefs. Cannon-Bowers and Salas (2001) propose task-specific knowledge, task-related knowledge, knowledge of teammates and attitudes/beliefs as the four domains. What is definite, however, is that, regardless of the label for the domains, shared information is critical to team performance. Both domain lists are attempts to describe the process engaged in by the team members to determine what is going on around them (Klimoski & Mohammed, 1994).

Team schemata are ways of organizing and processing new information based on prior experience (Rentsch, Heffner, &

Duffy, 1994). Because schemas are based on previous experience and knowledge, it would seem that individuals from similar work backgrounds and knowledge bases would form more successful teams. Team member schema similarity (TMSS) refers to the degree to which team members' schemas are comparable and compatible (Rentsch & Woehr, 2004). There are two components to TMSS: team member schema congruence and team member schema accuracy. Team member schema congruence is the degree to which team members' schema are identical. Team member schema accuracy is the degree to which a team member's schemas match some target schema, such as other group members' schemas (Rentsch & Woehr, 2004).

C. NATURALISTIC DECISION MAKING

Naturalistic decision making (NDM) encompasses those decisions that are made in complex, real-world settings. "[T]here are four key features of naturalistic decision making: dynamic and continually changing conditions, real-time reactions to these changes, ill-defined goals and ill-structured tasks, and knowledgeable people" (Klein, Orasanu, Calderwood, & Zsambok, 1993). Additionally, there are eight factors that characterize NDM: ill-structured problems, uncertain dynamic situations, shifting, ill-defined, or competing goals, action/feedback loops, time stress, high stakes, multiple players, and organizational goals and norms (Klein et al., 1993). NDM is difficult enough when there is a single individual making the decision. NDM in a team environment is more complicated because "…the existence of more than one information source and task perspective… must be combined to reach a decision" (Orasanu & Salas, 1993).

NDM can be readily applied to the military. Military operations are usually defined by an operational plan or guidelines. In many instances, however, circumstances beyond the control of the personnel force that plan or those guidelines to be abandoned. The resulting decisions, oftentimes made by lower echelon troops, are very much in the purview of NDM. An example provided by Orasanu and Salas (1993) is the shooting down of an Iranian airliner by the U.S. Naval warship USS VINCENNES. The crew of the VINCENNES mistook the airliner for an attack aircraft and, in a situation that embodies all eight of the factors that characterize NDM, the Commanding Officer decided to fire on the aircraft.

Since NDM in a team environment is an even more complex equation, there are more contributing variables. Orasanu (1990) suggests that the establishment of shared mental models is a factor in successful group NDM. She argues that by forming shared mental models related to a wide variety circumstances, the team is more readily able to deal with the situations that require something other than a standard response.

Certain personality styles may be more able to handle NDM demands. As discussed previously, there has been no research done on personality styles and their effect on team performance. However, by examining the literature regarding individual personality traits and their effect on team performance, it is possible that certain personality traits, and possibly personality styles, would be better or worse suited to act in a NDM situation.

D. ADAPTIVE ARCHITECTURES FOR COMMAND AND CONTROL (A^2C^2)

Adaptive Architectures for Command and Control (A^2C^2) is an ongoing research project, funded by the Office of Naval Research, which focuses on exploring innovative team organizations and their effect on team performance. The purpose of the A^2C^2 program is to design team structures that are optimally suited for a team's mission (Macmillan, Entin, & Serfaty, 2004). The research in this thesis is similar to two previous A^2C^2 experiments.

In an experiment done in conjunction with the A^2C^2 research program (Levchuk, Pattipati, & Kleinman, 1998; 1999), a team at the University of Connecticut created a organizational structure for a simulated Joint Task Force (JTF) tasked with completing a mission that involved utilizing air-, sea-, and land-based forces. The completion of the objectives involved the utilization of more than one or all of the resources.

Team members were allowed to complete the task in an optimized organizational structure or a traditional structure. The optimized structure allowed each team member to be in control of enough resources to allow for the independent completion of the objective. The traditional structure allowed each team member to control only one type of asset; either all the air-based forces, all the sea-based forces, or all the land-based forces. The traditional style forced cooperation between team members in order to complete the mission. Team performance was measured by the accuracy with which the teams delivered supplies to the specified areas. The team organized using the optimized structure achieved superior results, in all aspects, to the team utilizing the traditional structure (Macmillan et al.,

2004). The lower communication and coordination requirements for the optimized team resulted in better team performance (Macmillan et al., 2004).

The second experiment involved a simulated humanitarian mission, with the team tasked with the planning and execution of an airlift operation. Three types of planes were used: food supply planes, medical supply planes and Combat Air Patrol (CAP) planes. This experiment utilized two organizational structures: functional and divisional. The functional structure is similar to the traditional JTF structure from the University of Connecticut experiment in that each team member focused on one area of the airlift operation. The divisional structure is similar to the optimized JTF structure; however, each individual was assigned only some of the resources of each type, not necessarily enough to complete the objective autonomously. The team performance measure was the percentage of the time the team managed to deliver 100% of the supplies to the correct location. Team accuracy was higher for the functionally structured teams than it was for the teams under the divisional structure (Macmillan et al., 2004).

The JTF and the humanitarian airlift experiments suggest that the lower the need for coordination and, subsequently, the lower the need for communication to accomplish a task or mission, the better a team will perform. McMillan et al. (2004) propose that the reduced need for coordination and the subsequent need for communication significantly decreased the workload on the team members. The decreased communication requirement allowed the personnel to focus more attention on the actions of the other team members. In a related study, Fussell,

Kraut, Lerch, Scherlis, McNally and Cadiz (1998) found that overloading teams with the effort of excessive communicating and monitoring communications could possibly overwhelm the team and prevent them from actually accomplishing the task. Additionally, the communication between team members in the JTF and airlift scenarios was more of the information transfer type, rather than requests for information. The low communication anticipation ratio, or ratio of the number of communications transferring information to the number of communications requesting information, was a result of the team members being more aware of the tasks being performed by the other team members. The personnel in the divisional structure of the airlift scenario were not given all the necessary resources to complete the mission and therefore had to engage in some degree of verbal coordination, thereby reducing team performance.

E. TEAM COMMUNICATION

When measuring the communication between team members, it is helpful to have criteria for classifying different types of communication. Miller and Shattuck (2003) proposed 13 different types of communication: perception, comprehension, projection, pull, response to pull, push, decision/tasking, decision request, coordination, coordination request, clarification sought, clarification provided, and acknowledgement. These 13 categories are similar to the communication types proposed by Entin (1996). Entin proposed seven distinct types of communication: information request, information transfer, action request, action transfer, coordination request, coordination transfer, and acknowledgement. The different types of

communication can be used to compare and contrast what different teams determined to be critical information and how they communicated that information.

F. SUMMARY

The formation of successful teams is not a simple task. There are many factors that must be taken into consideration. Individual personality traits and styles, task type, team shared cognition, team schemata and command and control organization are but a few of the many factors that may affect team performance.

Research suggests that some personality traits may be more predictive of high team performance than others. Task type also plays a role in team performance, as different types of teams are more capable of adapting to and performing different types of tasks. Team shared cognition and team schemata are important considerations as they are the basis for why team members make certain decisions. Finally, the command and control organization of a team is important as it delineates who is going to control which aspects of the team.

Based on the previous research, this thesis will assess whether homogenous teams of participants with a personality style of highly agreeable and highly conscientious (A+C+) will perform better than homogenous teams with a personality style of low agreeableness and low conscientiousness (A-C-). Additionally, the thesis will assess whether teams operating in an independent team organization will perform better than teams utilizing the cooperative team organization.

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III. EXPERIMENTAL METHOD

Measuring team performance is a difficult task. Some studies focus on whether or not the team achieved its objective regardless of the internal processes. Others are more interested in team dynamics and information flow. For the purpose of this experiment team performance is examined as a function of task completion and communication. C3fire, a computer-based microworld, is used as a platform in which an environment is provided where team performance can be measured in a classroom setting.

C3fire was created by Rego Granlund and Henrik Artman at the Department of Computer and Information Science and the Department of Communication Studies at Linköping University in Sweden. “The goal was to provide a tool that allowed team training and controlled studies of co-operation and coordination in dynamic environments” (www.c3fire.org). The C3fire microworld is a firefighting scenario defined by a 40 x 40 grid of cells. The fire spreads through the cells at a predetermined rate, which can be manipulated by the experimenter. Participants utilize firefighting trucks, water trucks and fuel trucks in an effort to extinguish the fire. The C3fire user interface consists of a map superimposed over the 40 x 40 grid, a clock, a unit status panel, an e-mail utility panel and a truck destination panel (See Figure 2). It is the responsibility of the participants to be aware of fuel and water levels for the firefighting trucks. The water trucks must keep the fire trucks supplied with water; the fuel trucks must keep the fire trucks and water trucks supplied with fuel.

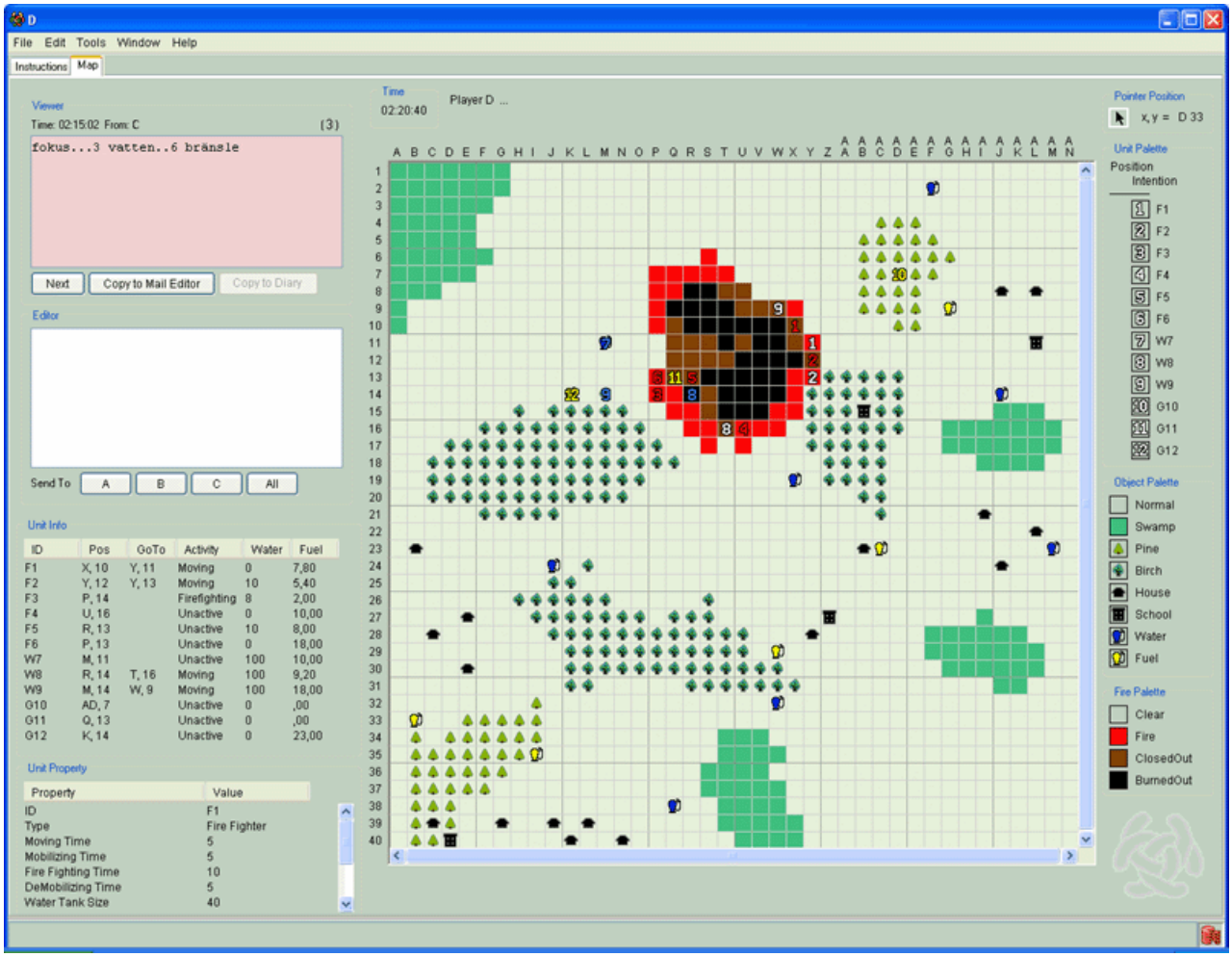

Figure 2. C3fire user interface. (from www.c3fire.org)

A. VARIABLES

1. Independent Variables

- NEO FFI Personality Profile scores
- Individual personality styles
- Team organizational structure

2. Dependent Variables

- C3fire task performance – the number of cells in the 40 x 40 grid that are burned, on fire, and have been extinguished at the completion of the scenario
- The number of messages sent between team members during the scenario
- The type of messages sent between team members during the scenario

B. PARTICIPANTS

For this study, the participants were military officers or civilians currently attending or working at the U.S. Naval Postgraduate School. Both U.S. military and foreign military officers participated in the study.

Thirty participants were identified from an initial distribution of 117 NEO-FFI surveys. There were 24 males and six females ranging in age from 26-42. The average age was 32.7 years (standard deviation 4.68). There were 15 U.S. Navy Lieutenants (O-3), 7 U.S. Navy Lieutenant Commanders (O-4), 2 United States Marine Corps Captains (O-3), 1 United States Air Force Major (O-4), 1 Greek officer, 1 Singaporean officer, and 1 Brazilian officer. Four teams were all male and six were mixed gender. Additionally, five teams were comprised of all U.S. military, three teams were mixed U.S. and foreign military, and two teams were mixed U.S. military and civilian NPS students. Table 2 shows team composition.

Team ID	Composition Age, Sex, Service, Rank	Team ID	Composition Age, Sex, Service, Rank
A+C(1)	26,F, USN, LT 34, M, USMC CAPT 26, M, USN, LT	A-C-(1)	29,F, CIVILIAN 36, M, USN LCDR 36, M, USN LCDR
A+C+(2)	35, M, USAF, MAJ 27, M, USN, LT 38, M, USN, LCDR	A-C-(2)	31, F, SINGAPORE 30, M, USN LT 29, M, USN LT
A+C+(3)	30, M, USN LT 41, M, USN LT 26, M, USN LT	A-C-(3)	28, F, CIVILIAN 29, M, USN LT 29, M, USN LT
A+C+(4)	35, M, USN LCDR 31, M, USN LCDR 40, M, USN LCDR	A-C-(4)	31, M, USN LT 31, M, USMC, CAPT 37, M, USN LT
A+C+(5)	33, M, GREECE 33, F, USN LCDR 31, M, USN LT	A-C-(5)	42, F, USN LT 40, M, USN LT 37, M, BRAZIL

Table 2. Team Composition

The student body of the Naval Postgraduate School consists of approximately 2,000 students, so it was not possible to form all teams with people that had never met or had classes together and had the requisite NEO scores. The NEO-FFIs were tracked based on when and where they were distributed. When possible, teams were formed from personnel who had received their NEO at different times, in different classes. This decreased the likelihood that the team members would be well acquainted. Furthermore, teams were instructed to arrive for the experiment in civilian attire to eliminate any rank or service bias. Additionally, participants were

encouraged to minimize introductions and interactions before the experiment.

The experimental procedures were screened and approved by the Naval Postgraduate School Internal Review Board (IRB), according to American Psychological Association (APA) standards. All participants signed an informed consent form which notified them of their rights as participants in the experiment.

C. APPARATUS

1. NEO Five Factor Inventory

The NEO FFI was used to measure the personality traits of each participant. Results from the NEO-FFI provided information regarding the participants' measure in each of the five personality traits.

2. Personality Styles Utility

At this time, there is no name for the utility that was used to define personality styles. The concept of styles on interactions and personality styles is mentioned briefly in Paradigms of Personality Assessment (Costa & Piedmont, 2003). The personality styles used in this study were taken directly from scales provided in the Wiggins Paradigms of Personality Assessment text.

3. C3Fire

The C3Fire program was run on two servers. All client computers were identical. C3Fire requires approximately 250 MB of free disk space on the server computer.

a. Server One Specifications

- 24″ Dell monitor
- Dell Optiplex 745 desktop computer
  - Windows XP O/S
  - Intel Core 2 CPU, 2.66 GHz, 3.0 GB RAM
  - Broadcom NetXtreme 57xx Gigabit Network Controller

b. Server Two Specifications

- 17″ Dell monitor
- Dell XPS 600 desktop computer
  - Windows XP O/S
  - Intel Pentium 4 CPU, 3.60 GHz, 2.0 GB RAM
  - NVIDIA nForce Network Controller

c. Client Computers Specifications

- 20″ Dell monitor
- Dell Optiplex 745 desktop computer
  - Windows XP O/S
  - Intel Core 2 CPU, 2.66 GHz, 3.0 GB RAM
  - Broadcom NetXtreme 57xx Gigabit Network Controller

D. PROCEDURE

The NEO-FFI surveys were distributed and subsequently scored, and participants were placed into groups based on their scores, placing them in either the A+C+ personality style or the A-C- personality style. Participants were asked

to complete two 10 minute sessions with the C3fire simulation. Two C3fire servers were utilized, allowing two teams to complete the simulation at the same time, if needed. The experiment was conducted in the Human Systems Integration Laboratory (HSIL) at the Naval Postgraduate School.

Upon arrival at the HSIL, each team was given a short PowerPoint introduction to the C3fire program and the parameters of the experiment. The participants were then given one minute to determine their preferred initial team organizational structure, either cooperative or independent. The cooperative structure allowed each team member to control all the trucks of one resource type (firefighting, water, or fuel). The independent structure allowed each team member to control one truck of each resource.

After the team had specified its preferred team structure, the team members were each seated at a C3fire base. Each C3fire base consisted of three C3fire client computers communicating with a C3fire server. The two C3fire bases were separated by a wall, and each computer was surrounded on three sides by 5’ tall partitions, completely blocking each participant from the view of any other participant, in order to limit interference between the groups and individuals. The computer that each participant was seated at was randomly determined by the participants. After being seated at the client computer, the participants were given time to familiarize themselves with the C3fire program and the associated user interface. A paper instructional packet was distributed to augment the initial C3fire instruction. The team then completed a five minute C3fire scenario for further program familiarization. Before

the start of the first scenario, each team was asked if they felt comfortable with the operation of C3Fire, and all questions or concerns were addressed before the start of the experiment. The C3fire client computer setup is shown in Figure 3.

Figure 3. C3Fire client computer station.

When the participants indicated that they were sufficiently familiar with the experiment and C3fire, the first 10 minute scenario was started. The first scenario was run with the team operating in their chosen organizational structure. Upon completion of the first scenario, a short debriefing was held to answer any questions and address any concerns. After the debriefing, the team was instructed to form into the organizational structure that they did not use in the first scenario. The second 10 minute scenario was then completed using the alternate organizational structure. Upon completion of the second scenario the teams were dismissed from the experiment.

IV. RESULTS

A. SUMMARY STATISTICS FOR TEAM COMPOSITION

Teams were formed based on personality styles, either A+C+ or A-C-. Of the 90 completed NEO FFI surveys, 40 (44%) were identified as either A+C+ or A-C-. As defined by Costa and Piedmont (2003), A+ and C+ personalities are characterized by a normalized agreeableness and conscientiousness score greater than 50. Conversely, A- and C- personalities are characterized by normalized agreeableness and conscientiousness scores less than 50. The normalized score of 50 correlates to a raw score of 32 in agreeableness and 34 in conscientiousness for males, and raw scores of 34 in agreeableness and 35 in conscientiousness for females. An effort was made to form teams with similar A and C score averages. Teams are distinguished by their personality style and number to delineate teams within a personality style. Table 3 shows the average agreeableness and conscientiousness score and standard deviation for each team.

	A	C		A	C
Team	**Score**	**Score**	**Team**	**Score**	**Score**
A+C+(1)	35.33	40.67	A-C- (1)	27.67	30.67
A+C+(2)	34.33	39.00	A-C- (2)	28.00	25.33
A+C+(3)	35.00	38.67	A-C- (3)	26.00	25.33
A+C+(4)	34.00	39.00	A-C- (4)	26.33	26.67
A+C+(5)	34.00	39.33	A-C- (5)	25.67	25.33
St. Dev.	0.61	0.78		1.04	2.31

Table 3. Average Team Agreeableness and Conscientiousness Score

Prior to the start of the first scenario, each team selected either the cooperative team organization or the independent team organization for their first scenario run. The teams did not know that they would run a second scenario in the alternate organization. Table 2 shows the team organization preference for each team.

Team	1st Run Team Organization	Team	1st Run Team Organization
A+C+(1)	Cooperative	A-C-(1)	Cooperative
A+C+(2)	Cooperative	A-C-(2)	Cooperative
A+C+(3)	Independent	A-C-(3)	Cooperative
A+C+(4)	Cooperative	A-C-(4)	Cooperative
A+C+(5)	Independent	A-C-(5)	Cooperative

Table 4. Team choice for initial team organization

B. SUMMARY STATISTICS FOR TEAM PERFORMANCE

Three aspects of the team performance were analyzed: C3Fire cell status at the conclusion of the scenario, density of team communication, and communication type diversity.

1. C3Fire Cell Fire Status

At the end of each scenario the cells of the C3Fire matrix were in one of four states: normal, on fire, extinguished, or burned out. A normal cell was never on fire; extinguished means that the team utilized its assets to put out the fire; and burned out means that the space burned out before the team was able to extinguish the fire. The C3Fire program specifies that the likelihood of a normal cell catching fire is dependent on the number of cells around it that are on fire and how long those cells have

been on fire. Therefore, the number of cells on fire throughout the scenario is related to the number of cells that have burned out or been extinguished. Additionally, the longer a cell is on fire, the more likely it is that it will be burned out instead of extinguished.

A+C+ teams had an average of 45.00 (SD=37.83) cells on fire at the conclusion of the scenario. Additionally, A+C+ teams extinguished an average of 29.10 (SD=7.88) cells that were on fire and allowed an average of 107.10 (SD=46.44) cells to burn out. A-C- teams had an average of 42.30 (SD=37.83) cells on fire, 23.90 (SD=7.32) cells extinguished and 105.00 (SD=49.92) cells burned out. Three teams (A+C+(4), A-C-(2), and A-C-(4)) were able to completely extinguish the fire and account for the high standard deviation for cells on fire and cells burned out. Figure 4 shows the average final cell status for A-C- and A+C+ teams.

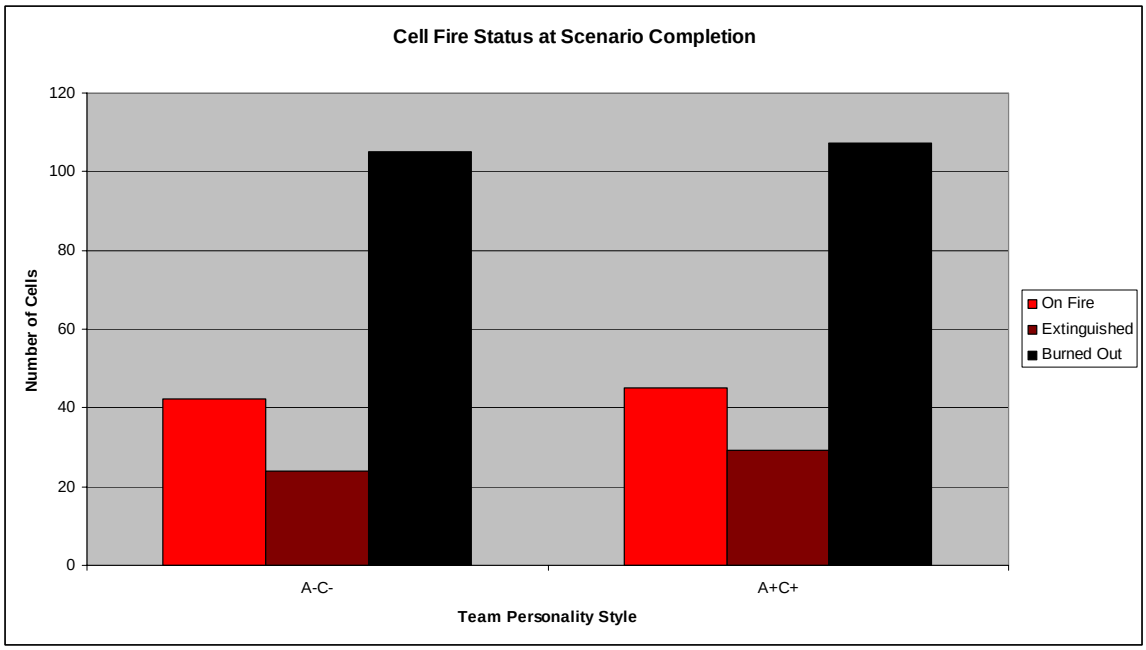

Figure 4. Average cell fire status at scenario completion.

Teams utilizing the cooperative team organization had an average of 49.60 (SD=37.55) cells on fire at the conclusion of the scenario. Additionally, cooperative teams extinguished an average of 25.90 (SD=6.97) cells on fire and allowed an average of 107.10 (SD=60.97) to burn out. Teams operating in the independent team organization had an average of 37.70 (SD=30.17) cells on fire, 27.10 (SD=9.02) cells extinguished and 105.00 (SD=30.52) cells burned out. Again, the three teams, two using the cooperative organization (A+C+(4) and (A-C-(2)) and one using the independent organization (A-C-(4)), that were able to completely extinguish the fire account for the high standard deviations for cells on fire and cells extinguished. Figure 5 shows the average final cell status based on team organization. Figure 6 shows the final cell status based on team personality style and team organization.

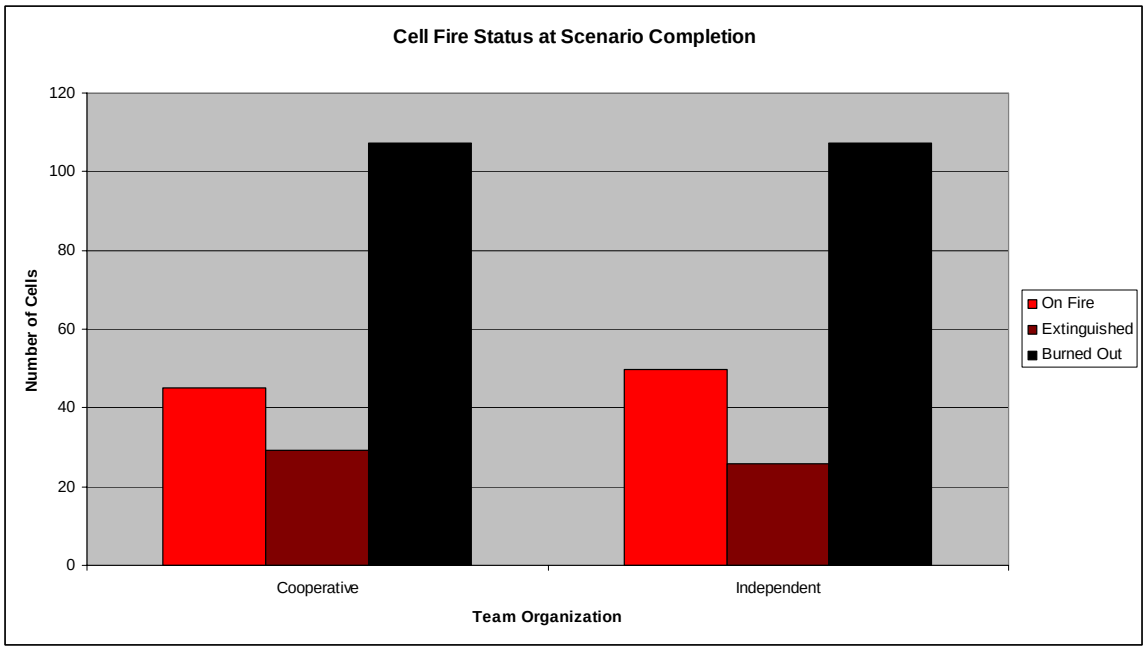

Figure 5. Average cell fire status for cooperative and independent teams at scenario completion.

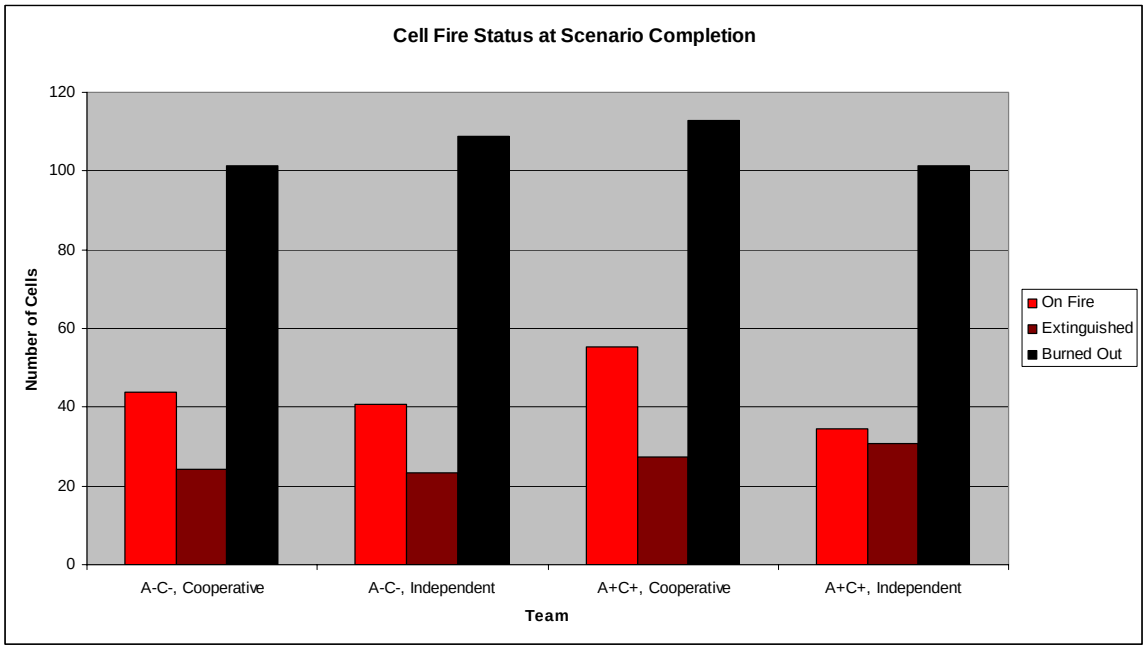

Figure 6. Average cell fire status, based on team personality style and team organization, at scenario completion.

The largest variation between the groups is the average number of cells on fire at the end of the scenario. This variation can be explained, however, by the fact that the A+C+ cooperative teams was the only group without a team that completely extinguished the fire, i.e., no cells on fire at the end of the scenario.

In addition to the descriptive statistics, a multivariate analysis of variance (MANOVA) was conducted. The three dependent variables were cells on fire, cells extinguished and cells burned out. The independent variables were team type based on personality style and team type based on team organization. The MANOVA confirmed the lack of

statistical significance for the results based on personality style (F=.02, p=.98) and team organization (F=1.61, p=.23).

For deeper analysis, the teams identified by personality styles were further examined. The distance between each team member's raw agreeableness and conscientiousness score and the cutoff score for the opposite of that individual's trait classification was calculated. Then, the team average for difference between trait score and minimum trait scores was calculated. The agreeableness and conscientiousness score differences were added to provide an average total group score. Table 5 shows these average total group scores.

Team	Dist from A-C-	Team	Dist from A+C+
A+C+(1)	4.50	A-C-(1)	-4.33
A+C+(2)	3.67	A-C-(2)	-6.83
A+C+(3)	3.83	A-C-(3)	-7.83
A+C+(4)	3.50	A-C-(4)	-6.50
A+C+(5)	3.17	A-C-(5)	-8.00

Table 5. Difference between Group Average and Alternate Personality Style Minimum Score

The difference between the scores was then compared to the number of cells on fire at the end of each scenario. Because three teams were able to extinguish the fire, and the fact that the number of cells on fire is dependent on the number of cells extinguished and burned out, the comparison gives the most accurate assessment of team performance. Figure 7 shows the correlation between trait score difference and cells on fire at the end of the scenario ($r^2 = .023$, $p < .001$). The small r^2 value indicates

a small correlation between trait score difference and team performance as defined by cells on fire at the end of the scenario. The small p value indicates that there is minimal chance of falsely rejecting the null hypothesis that there would be no correlation between trait score difference and team performance.

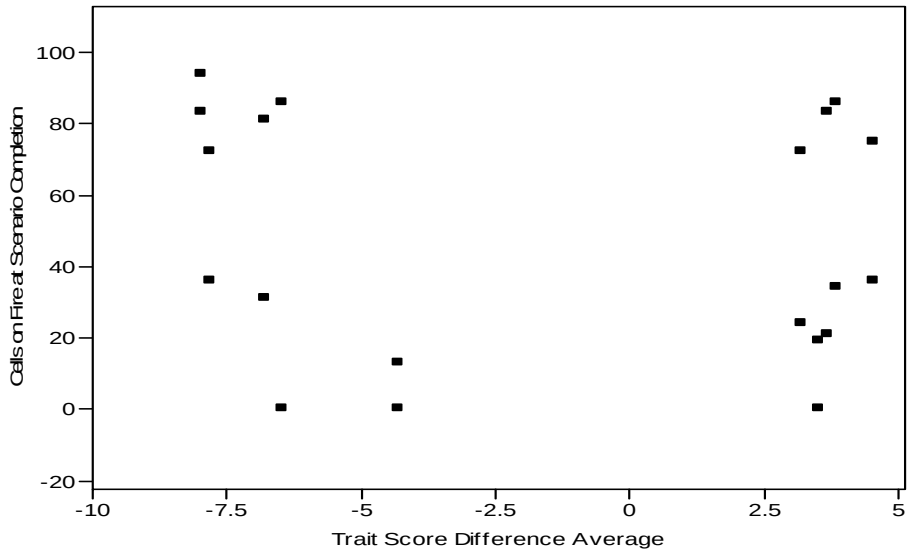

Figure 7. Relationship between Trait Score Difference and Cells in Fire at Scenario Completion

2. Communication Density

Team performance was also analyzed by examining the number of messages sent between team members during each scenario. The C3Fire program contains a message sending utility similar to instant messaging. Team members were not allowed to verbally communicate during the scenarios; therefore, text messages were the only way to pass information. As will be discussed in the next section, some of the communication was related to the scenario and some of the communication was extraneous chatter, unrelated to the

scenario. At the start of each scenario, C3Fire sent a message to each player indicating the location of the fire. These C3Fire generated messages and related participant responses were not included in the team communication analysis. Figure 8 shows the average number of total messages sent per scenario for each team type and Figure 9 shows the total number of messages sent by team.

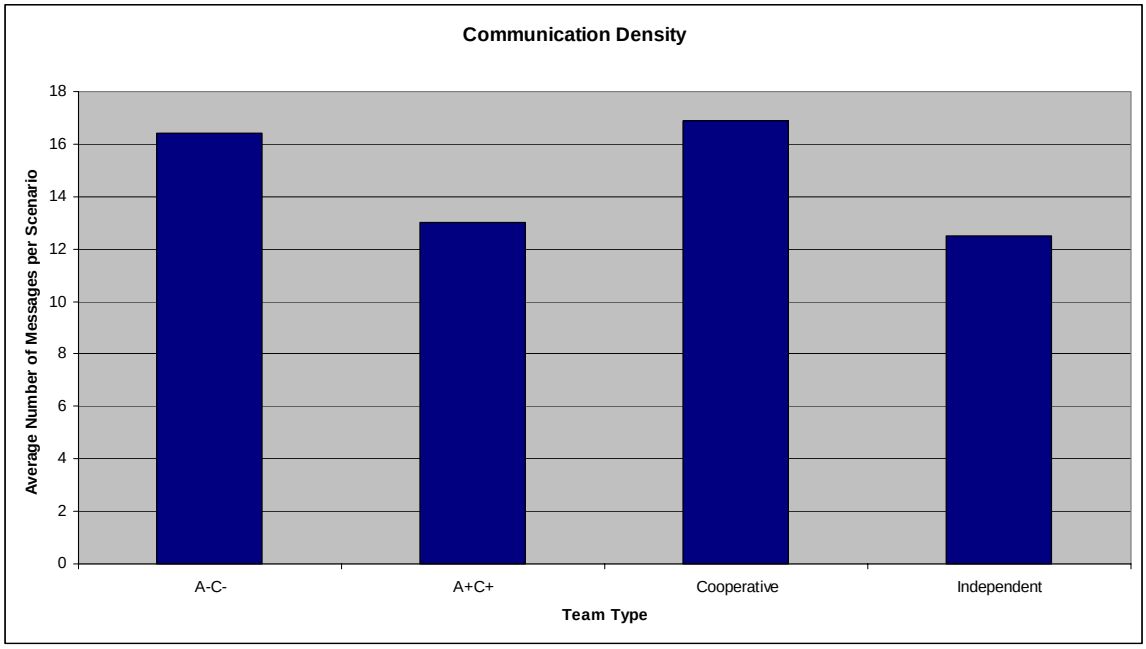

Figure 8. Communication Density for each Team Type

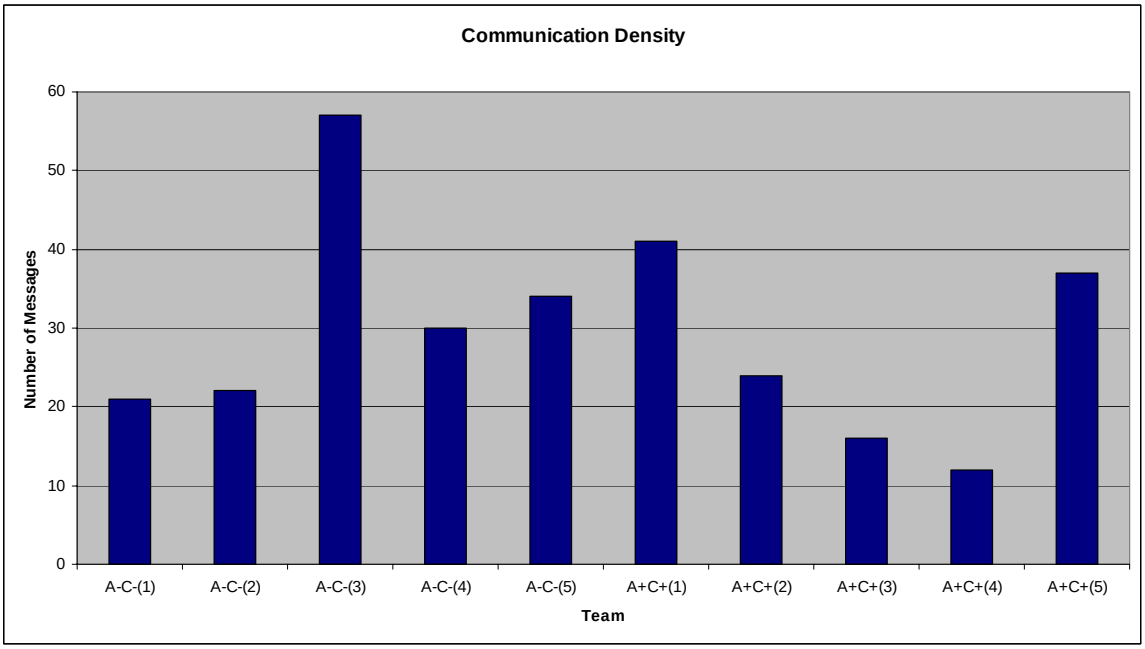

Figure 9. Total Messages Sent per Team

An analysis of variance (ANOVA) was conducted using number of messages as the dependent variable and team type as the independent variable. Again, no statistical significance was found for teams based on personality style ($F=.80$, $p=.38$) or teams based on team organization ($F=1.39$, $p=.25$).

Again, for deeper analysis, the teams identified by personality styles were further examined, this time with respect to communication density. Figure 5 shows the relationship between trait score difference and communication density ($r^2 = .067$, $p < .001$). As with the previous analysis, the small r^2 value indicates a low correlation between personality style and communication density.

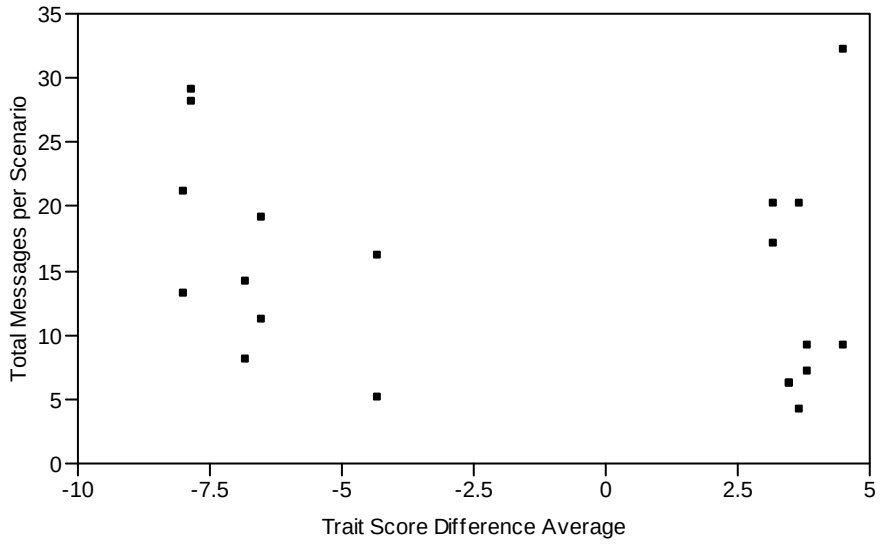

Figure 10. Relationship between Trait Score Difference and Communication Density

3. Communication Type

The communication between team members was categorized into six of the thirteen distinct types identified by Miller and Shattuck (2003): perception, coordination, clarification request, clarification provided, projection, and acknowledgement. A seventh category, extraneous chatter, was added to account for communication that did not relate to the scenario. Figure 11 shows the breakdown of communication for teams identified by personality style; Figure 12 shows the breakdown of communication for teams based on team organization.

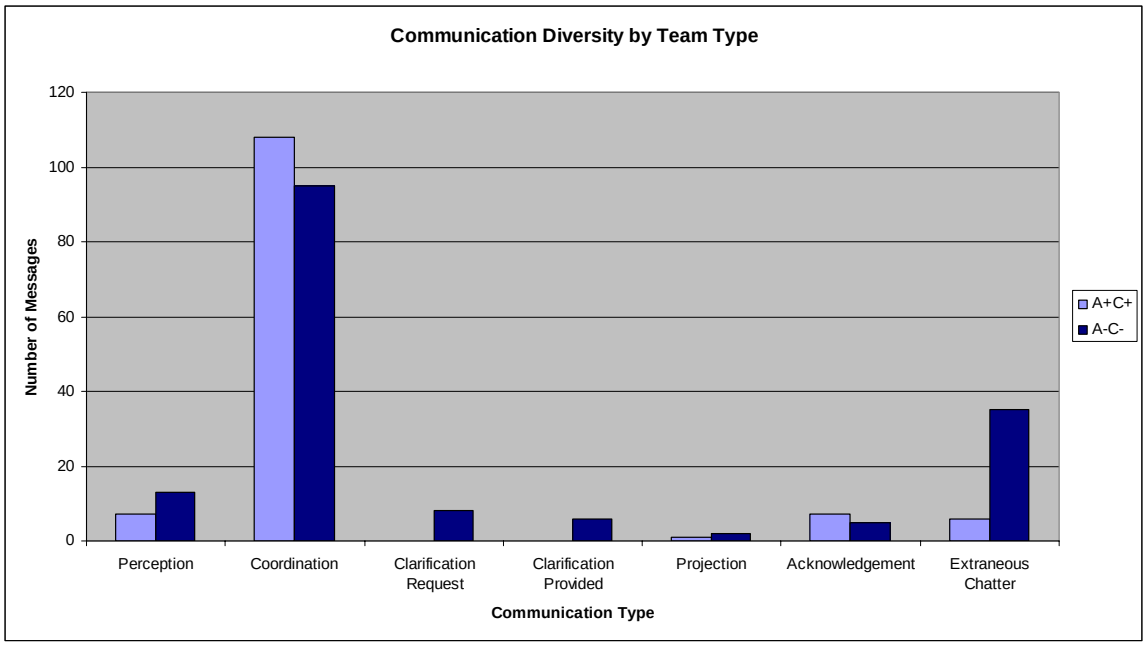

Figure 11. Communication Diversity by Personality Style

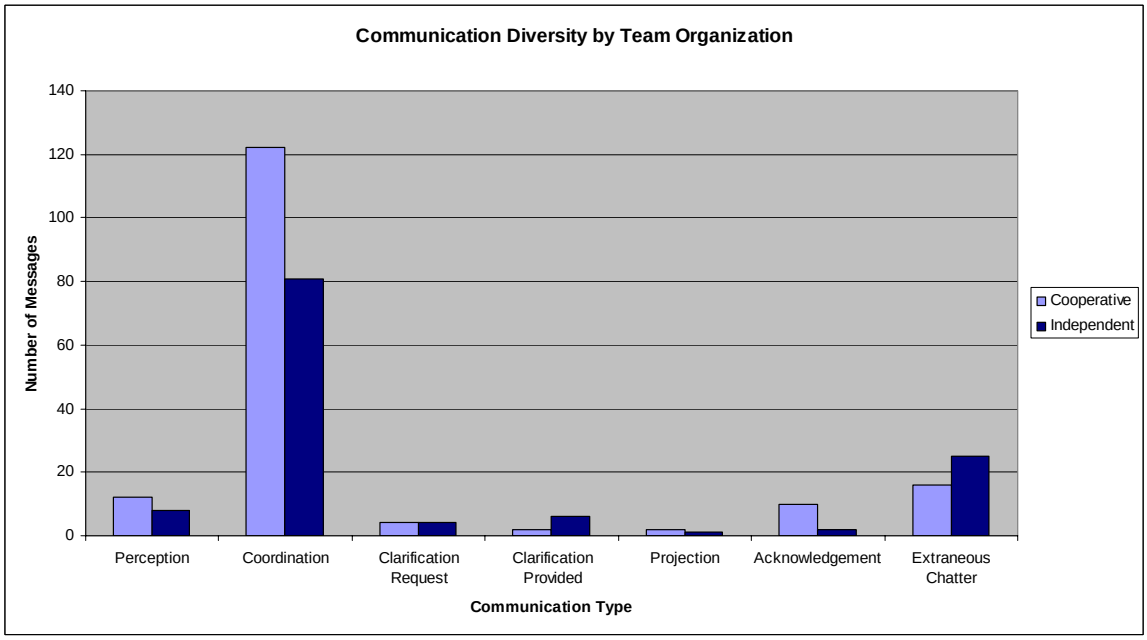

Figure 12. Communication Diversity by Team Organization

Further analysis was conducted by applying Student's t-tests to the team totals for coordination and extraneous chatter messages. The total number of messages for the other

message categories was insufficient to provide significant results. The t-tests were conducted with respect to personality style, team organization, and team organization within the personality styles. The t-tests revealed no significant relationships. Table 5 shows the results of the t-tests.

	Coordination Messages t-score	Extraneous Chatter t-score
Personality Style	2.10	2.10
Team Organization	2.10	2.10
A+C+/Team Organization	2.31	2.31
A-C-/Team Organization	2.31	2.31

Table 6. Student’s t-test Results for Message Type

V. DISCUSSION

The hypothesis that team personality style and organization has an effect on team performance was not supported by this research. There were no statistically significant differences in team performance for A+C+ teams and A-C- teams when team performance is measured by the number of C3Fire cells on fire at the end of a scenario. The literature review for this thesis showed a varying degree of correlation between personality traits and team performance, but the correlation was never greater than r=.51. So, while there is some correlation between personality traits and team performance, it is usually small. Across 10 scenarios for each personality style, the difference in the average number of cells on fire at the end of the scenario was 2.70 cells. While the A+C+ teams had fewer average cells on fire at the end of the scenario, the difference was not statistically significant. Interestingly, while shown to be not statistically significant as a part of the whole, out of 20 scenarios, A-C- teams completely extinguished the fire twice, while the A+C+ teams only extinguished the fire once.

There are several possible reasons why performance of teams high in conscientiousness and high in agreeableness did not differ from teams low in the same traits. One possible explanation for the lack of significance is the small number of participants in the experiment. Of 117 NEO personality surveys, only 30 participants were identified as meeting the requirements for the experiment. A larger sample may have provided more significant results. Also, the results of the personality surveys were not as diverse as may be needed to produce significant results. While it was

possible to form groups based on personality style, the difference between the groups (see Table 5) was not as large as it could have been. A larger disparity between the A+C+ groups and the A-C- groups may have yielded significant results.

Another possible explanation for the results is that the C3Fire program may not be appropriate vehicle for collecting data regarding team performance based on personality traits. Individuals' personality traits may have been more readily exposed had the scenario involved face to face interaction vice only electronic communication. Additionally, the C3Fire scenario length used, at 10 minutes, may not have been long enough to allow sufficient team development.

There were also no differences in team performance when teams were examined based on team organization. The original hypothesis that independent teams would perform better was not supported. Descriptive statistics show that teams working in the cooperative organization had, on average, 11.90 fewer cells on fire at the end of each scenario than independent teams, but with the small sample size and large standard deviation, the results were not statistically significant. Additionally, of the three teams that completely extinguished the fire, two teams were in the cooperative organization, while only one team was working in the independent setup. Furthermore, the one independent team that put out the fire extinguished 17 cells through firefighting efforts and allowed 53 cells to burn out. Conversely, the two cooperative teams that extinguished the fire put out 20 and 14 cells respectively, and allowed only seven cells to burn out totally. While it appears that the

team working in the cooperative organization performed better, large deviations in team performance caused inferential statistics to reveal no statistically significant difference.

A possible reason for the lack of difference between the performances based on team organization is the duration of the C3Fire scenarios. It is possible that if the scenario had lasted longer, a difference in team organizations would have been revealed. Additionally, the participants' lack of familiarity with the C3Fire program may have played a role in the team performance results. The lack of experience with the program may have forced some of the participants to focus on understanding how to use the program rather than focusing on the scenario and how to best utilize the assets. A longer familiarization period with the C3Fire program may have allowed for greater concentration on asset management.

The difference in total communication density for teams identified by personality traits was not statistically significant. A-C- teams sent an average of 3.4 more messages per 10 minute scenario, which equated to approximately one more message every three minutes. A-C-(3), comprised of one female civilian and two male U.S. Navy Lieutenants, sent a significantly higher number of messages than the other A-C- teams, the majority of which were extraneous chatter. If the A-C-(3) message total is eliminated, the average number of messages between the A-C- teams and A+C+ teams was nearly identical (13.38 and 13.00, respectively).

Cooperative teams sent an average of 4.40 more messages per scenario than independent teams. Even with the elimination of the outlying A-C-(3) team message totals, cooperative teams averaged 4.78 more messages per scenario.

These differences support the A^2C^2 research done by Levchuk, Pattipati, & Kleinman (1998; 1999), as the cooperative teams needed to utilize more communication to accomplish tasks.

The types of messages transmitted by teams identified by personality styles were nearly identical, except for messages identified as extraneous chatter. A-C- teams engaged in almost six times as much communication that was unrelated to the scenario than A+C+ teams (35 and 6, respectively). However, team A-C-(3) contributed 66% of the total A-C- extraneous chatter messages. Eliminating the A-C-(3) extraneous chatter messages yields a 12 vs. 6 advantage for the A-C- teams in messages unrelated to the scenario. The higher number of messages unrelated to the scenario for A-C- teams supports Costa and McRae's (1992) description of conscientious individuals as "…purposeful, strong-willed, and determined…" (Costa & McCrae, 1992, p. 16) The A+C+ teams appeared to be more focused on the task, as evidenced by their messages.

The types of messages transmitted by teams identified by organization were nearly identical except for coordination messages. Teams utilizing the cooperative team organization utilized a total of 122 coordinating messages over 10 scenarios, while independent teams transmitted a total of 81 coordinating messages. The increased number of coordinating messages for cooperative teams supports the previous research by Levchuk, Pattipati, & Kleinman (1998; 1999), as cooperative teams must coordinate the utilization of the team assets in order to accomplish the mission. However, previous A^2C^2 research (Levchuk, Pattipati, & Kleinman, 1998; 1999) shows that independent teams perform better because they have lower communication overheads. In

this case, the independent teams did have lower communication totals (coordinating messages and total message density), but showed no significant difference in the specified metric of cells on fire at scenario completion than the cooperative teams.

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VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSION

Given the importance of teams and team performance in current military operations, it is critical that we determine ways in which we can select team members and make assignments to teams that will lead to optimal performance. There is a great deal of interest in the research community in using personality traits as measured by NEO inventory for forming teams. The NEO personality survey identifies five individual traits that describe an individual's personality. It should not be assumed that these traits are independent of each other. It is likely that these traits interact with one another. Such interactions must be considered when attempting to use personality traits as a means of forming teams or predicting team performance.

The concept of personality styles, or the combination of selected traits, as proposed by Costa and Piedmont (2003), has not been researched sufficiently, yet may possibly hold many keys to understanding individual personalities and their effect on performance in both individual and team environments. In the present study, 30 individuals were organized into three person teams to participate in a team performance experiment. Team assignments were based on personality homogeneity, with participants categorized as either high in agreeableness and high in conscientiousness (A+C+) or low in agreeableness and low in conscientiousness (A-C-). The teams then completed

two 10 minute scenarios in the C3Fire microworld, a computer based firefighting simulation designed to measure team performance.

Contrary to the original hypothesis that A+C+ teams would outperform A-C- teams, there was no statistical difference in overall performance between the two team personality styles. Additionally, based on A^2C^2 concepts, teams were examined in either a cooperative or independent team organization. Again, the results did not support the original hypothesis that independent teams would outperform cooperative teams. The difference in the performance of the two team organizations was minimal. The previous A^2C^2 literature was supported by the communication density and communication type.

The application of the results of the study to the HSI domains of manpower, personnel and training, is, at this point, unclear. The use of personality surveys to determine who should, and should not, work together is an intriguing concept. The ability to optimize teams on all levels, from a two-person flight crew to a warship crew of 300 sailors, would create new demands for manpower and personnel planners. However, the cost on these planners may be surpassed by the benefits realized in terms of total system performance.

Using personality styles as a basis for forming teams is, at this time, a questionable strategy, at best. All 40 personality styles have to be examined in depth to understand fully their interactions and effects. Further, it is premature to use individual personality traits as a tool to assist in assigning teams. More research on these traits

and the manner in which they interact with each other is needed before such a selection strategy is adopted for military applications.

B. RECOMMENDATIONS

Empirical evidence with regard to personality traits and their effect on team performance must be present before the use of personality surveys as a selection and placement tool for military service can be seriously considered. Studies using military personnel in military tasks must be conducted to enhance the validity of the survey in a military context.

While the NEO has a good retest reliability, between .68 and .83 for the five domains over a six-month longitudinal study (Costa & McCrae, 1992), the results of a self-reported survey regarding an abstract concept such as personality are somewhat subject to variation dependent on the participant's mood or motivation. However, short of a detailed evaluation by a clinical psychologist, there seems to be no way to get a truly accurate assessment of individual personality. Research regarding the variation in NEO test/retest responses would be beneficial in that it could possibly yield a way to increase retest reliability.

The use of the NEO personality inventory to predict individual and team performance is a promising concept, but the metrics used to assess team performance must be refined. C3Fire is sufficient as a team performance environment for tasks that require minimal interactions, require little urgency, and there is minimal threat or consequences for failure. Research should also be conducted in realistic military settings. Obviously, experimentation can not be

conducted in actual wartime situations, but the military conducts a sufficient amount of training and demonstration exercises that can provide research opportunities.

Finally, the concept of personality styles offers potential for extensive research. There has been little research examining the interactions between the individual traits, much less the effect of the personality styles on individual performance. The examination of personality styles on team performance in this study may have been premature, as there is little data regarding the effect of personality styles on individual performance. With 40 possible personality styles, a comprehensive research project that would consider all styles would be a monumental undertaking. With regard to using personality traits for selection and placement in the military, further research is also needed.

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